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AUTHOR Bieber, Jeffrey P.; Blackburn, Robert T.
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ABSTRACT

An approach for studying faculty research productivity over time as measured by the number of scholarly articles published was developed and tested. The approach attempts to take into account the fact that both the amount of available professional journal space and the number of faculty competing for publications have changed over time by measuring productivity in real or constant units in much the same manner that economists use constant dollars over time. Four data sources were used in the study: "Ulrich's International Periodicals Directory;" "The Annual Bibliography of English Language and Literature;" "American Universities and Colleges;" and 20 journals selected at random within each discipline. The disciplines of biology, psychology, and English and the years 1972, 1980, and 1988 were chosen for comparison. Major findings were: there was almost twice as much space available for faculty publishing in 1988 as in 1972 while faculty numbers increased only slightly; faculty effort to publish needs to almost double in order to produce the same amount today as was produced in 1972 (in 1972 units, a 1988 article is only about half what it was then). Three appendices are: growth of journals by discipline, decision rules that guided the collection of data; and journal sampling data for the field of psychology. Contains 21 references. (SM)

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Faculty Research Productivity 1972-1980: Development and Application of Constant Units of Measure

Jeffery P. Bieber
Robert T. Blackburn

University of Michigan
Ann Arbor, MI

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Texas A&M University
Department of Educational Administration
College Station, TX 77843
(409) 845-0393

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Faculty Research Productivity 1972-1988: Development and Application of Constant Units of Measure

Introduction

As faculty production of knowledge grows in importance not only as a goal for faculty and their colleges and universities but also for the nation, properly assessing faculty output becomes an important problem. The critical questions of understanding how research activities are funded, how institutions aid or inhibit research activity, the transmission of research, the extent to which faculty take advantage of the resources available, all hinge on accurately measuring the quantity and quality of knowledge that faculty produce.

The aim of this inquiry is to develop and test an approach for studying faculty research productivity over time as measured by the number of scholarly articles published. While studies of faculty research productivity already exist, none take into account the fact that both the amount of available professional journal space and the number of faculty competing for publications have changed over time. This study presents an approach for measuring productivity in "real" or constant units in much the same manner that economists use "constant dollars" by developing the concepts of supply, demand, and competition as they apply to research productivity.

Background

Despite its recognized importance, faculty research productivity is not a simple construct, conceptually or empirically. Such questions as: Is one productive only when concrete objects result? Are faculty researchers productive when helping others clarify ideas? Is some research of higher quality than other?

These questions are but a sample from a long list one can make. Nonetheless, if for no other reason than convenience, one generally agreed upon measure of faculty research productivity, namely, publications, has emerged.[1] Publications are "things;" they are countable.

Recognizing that research productivity is becoming increasingly important to colleges and universities and their faculty alike, and that the evaluation of such productivity occurs along a single dimension, it is necessary that this measure be as accurate and reliable as possible.

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1. The argument that is often raised in discussions of faculty research productivity that focus on publication rates is that quantity of publications does not equal quality of publications. Further, there are increasingly greater numbers of productivity measures, equally as easy to quantify as publications, that represent faculty productivity. Computer software programs, patents, and copyrights are all examples of "things" that can be counted and that represent productivity. However, current practice almost exclusively utilizes printed publication rates.

The Literature

For the most part, research productivity has been examined from two perspectives. The first is from that of the information scientist. A field that has existed in various forms (e.g., as a first cousin to library science) over the years, information science has chiseled out an important position for itself with respect to productivity through its empirical and theoretical studies of information. And, perhaps more importantly from an educational researcher perspective, information scientists have employed increasingly sophisticated quantitative methods in attempts to measure the qualitative impact of productivity via citation indexing.

Research productivity has also been studied by educational researchers. Their interests have included the differences in productivity that exist between various types of institutions, faculty demographic characteristics (e.g., gender), and hard versus soft sciences. This research has focused on trying to more completely ascertain the individual and environmental qualities that are most closely linked to productivity.

Turning to the literature, research on faculty publication rates goes back at least three-quarters of century. Lotka (1926) took scientific productivity rates to be the number of publications produced over a given time period. Although his measure was originally developed for the hard sciences, contemporary researchers in information science continue to

strive to improve his work and its applicability to other fields (Voos, 1974; Pao, 1986).

Despite the fact that research was explicitly linked to the reward structure of some institutions as early as the 1890s, Wilson (1942) found that institutional appraisal of faculty performance placed little emphasis on research activity. In fact, it is argued by Kaplan (1964) that it was Sputnik that generated significant interest in empirically studying faculty and scientists' research productivity. If productivity was to be improved, the conditions surrounding scholarly productivity would first have to be better understood.

The 1960s saw an increase in studies examining research productivity. Pelz and Andrews (1966) published their classic work on faculty and scientists' productivity. Two years later Merton (1968) identified a phenomenon he termed the "Matthew Effect," -- the more, the more phenomenon. (Those who have, get.) Further, Merton mentored several of his students who also conduct research in the area (e.g., Crane, 1972; Zuckerman, 1977). A critical mass of knowledge accumulated on the productivity of scientists during the late 1960s and 1970s, so much so that a specialization in the field of sociology developed, namely, the sociology of science.

Scientific productivity continues to be an area of interest. The sophistication and perspectives from which data are examined continue to increase (see, for example, Creswell, 1985; Bentley & Blackburn, 1988; Lawrence, Frank, Bieber, Bentley, Blackburn, & Trautvetter, 1989). That research productivity has increasingly

become the criterion for faculty rewards within research universities (and is becoming increasingly the case in other types of institutions) is well understood by faculty. Consequently, extending the existing knowledge in this field has both theoretical and empirical implications.

The production of knowledge is also of public interest. The United States is becoming increasingly wedded to the production of knowledge. The old cliche that "knowledge is power" is taking on increasing significance. Entire corporate and societal structures are being developed whose purposes are to enhance the production, storage, ownership, and transfer of knowledge. That knowledge is exerting influence on the economy is unquestionable: The "knowledge industry" continues to grow despite the difficulties in measuring it. (See, for example, Machlup, 1980; Bearman, Guyneup, & Milevski, 1985). The productivity question--output per faculty member today in comparison to yesterday--remains unanswered.[2] Answering this question is the objective of this study.

Theoretical Framework

An economic framework is used to study research productivity over time. Employing economics in the study of higher education

2. So does change in quality over time.

is not new.[3] A basic economic principle-- "real" or constant units of measure--is used.

In economics, this principle is typically applied as a means to neutralize the influence of inflation when considering the rate of change a country has economically experienced in terms of its gross national product (GNP). Economists recognized that the effects of inflation obscured accuracy in the measure and interpretation of GNP and developed the principle of "constant dollars" to eliminate the influence of inflation.

Since developed by economists, however, the concept of inflation has been widely, sometimes vaguely, used by others to describe many forms of apparent growth that are actually artificial. As generally understood, inflation is interpreted to mean that the level of real growth is masked.

With respect to research productivity, one way that "inflation" has been used (Adelman, 1989) is in an individual's reporting of published articles. That is, researchers today are no longer counting only published articles when reporting their productivity but are inflating their counts by including "research notes," published abstracts, and the like. Another form of inflation results from increased multiple authorship when each author claims the published piece on the vita.[4] While inflation may actually exist in these forms, it is not the type

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3. Breneman (1970) studied Ph.D. production from an economic perspective. McGuire, Richman, Daly, and Jorjani (1988) examined how efficiently research universities establish their reputation.

4. We know that this phenomenon is occurring in some disciplines. See Wilner, 1985.

of inflation that this study addresses. For the purposes of this study, inflation is defined as a disproportionate increase in the amount of space in which faculty can publish their research (over a specific time period) when compared to the number of faculty members who might desire to have their work published. This study is examining "inflation of opportunity for publication" and whether such inflation has come to exist over the past sixteen years.

Regardless of what one's specific definition of inflation is or what one believes might be being inflated, a universal principle of inflation is "constancy," a standard against which subsequent growth or change is to be measured. This study utilizes the concept of constant units of measure by applying the concept to the number of articles a faculty member produces in "real" terms over a given period of time. In much the same manner that economists have used "constant 1972 dollars" to measure the growth of the economy, this study uses "constant 1972 publication units" to determine whether faculty were producing more or less in 1988 than they were in 1972. This analysis allows for the neutralization of the fact that both the number of journals (and the amount of space within the journals) available to researchers in which to publish their work and the number of faculty potentially interested in having their research published have changed. The manner in which these changes get translated into the knowledge production marketplace is described below.

In the knowledge production market journal articles constitute a "supply" component. The suppliers of knowledge,

namely, the faculty, constitute the "demand" component. The ratio of the supply and demand represents competition or tension in the market, that is, the degree to which the supply is adequate for the demand.

Less cryptically, in the marketplace there is a supply of journals (a certain amount of space) in which faculty can publish their research. There is also a demand on the part of faculty members for greater numbers of journals because (among other things) of the increasing significance publications are acquiring in promotion, tenure, and merit salary decisions. However, because there is not an adequate supply to meet all of the demand,[5] competition exists.

Competition in the knowledge production marketplace is a measurable entity. It can be understood as the relationship between supply and demand and can be computed as a ratio: supply/demand=competition. This quotient, if computed over time using "real" units of supply and demand, can provide insight into not only whether faculty are in greater competition with each other for the opportunity to publish but also whether faculty are more productive overall.

It should be noted that by casting supply as the amount of journal space and demand as the number of faculty, this study's focus is on faculty. The data are being viewed and analyzed from

5. Manuscripts are rejected for publication, at rates exceeding 80% by the most highly rated journals in the social sciences.

the faculty's perspective. The faculty are the ones in competition with each other for journal space.[6]

By way of illustration, when particular items (e.g., natural resources) are scarce, their value increases. For example, if there is a fixed amount of gold available and no more is to be mined, assuming the population was to remain the same, gold would retain its value over time, everything else being equal. The same number of people would have access to the same amount of gold. If, however, the population was to remain the same but more gold was mined, the value of gold would decrease. For one's real or constant worth in gold to remain the same, physically having more gold is necessary. Even if there was not a set monetary value placed upon a given quantity of gold, the value of any given quantity would decrease. This is "gold inflation." For people to be able to determine how much gold they would currently need for it to equal the worth of their gold prior to the new mining of gold, they would have to calculate a gold inflation rate. This rate of inflation, also known as a "deflator," is a percentage change. During a period of inflation

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6. An alternative study could be designed using the same data sources that focuses on the competition between journals to publish the research conducted by faculty at particular kinds of institutions (e.g., Research I universities as opposed to Doctoral-Granting II institutions). Such a study could be characterized as "from the journals' perspective" and would have the journals in competition with each other and representing the demand component while the faculty's research (articles submitted for publication) would be the supply component.

We also note that the concept of "price" is often involved when dealing with supply and demand. We have no way of estimating cost for a faculty member to produce an article and hence do not introduce this construct.

this rate of inflation increases. Conversely, a period of deflation--when the amount of gold remains constant while the population increases -- requires a rate of deflation, an "inflator," to determine how much more valuable an amount of gold has become due to the increased competition.

To recast the above scenario into a formula, let

w = amount (real number of units) of gold at T1 (this is the "base" amount of gold)

x = population at T_1

y = amount (real number of units) of newly mined gold at T_2

z = a real number increase in population at T_2.

ki= constants at time 1 (k_1), time 2 (k_2),.... time n (kn)

A steady state economy or one at equilibrium would be characterized as

$$(w / x) = k_1.$$

In such a situation more gold is not being mined and the population is not increasing.

A later situation where more gold is mined (while the population remains constant) would be expressed as

$$(w + y) / x = k_2.$$

In these circumstances, gold is being inflated (its actual value is decreasing) because there is now more gold available for each individual. Its value, which it accrues as a function of its scarcity, decreases as its scarcity decreases.

On the other hand, if the amount of gold were to remain the same and the population increased, the formula is

$$w / (x + z) = k_2.$$

This formula simultaneously characterizes a period of gold deflation, greater scarcity of gold, and increased competition for gold.

Reconsidering briefly a period of gold inflation, assume that the number of units of gold one possessed had increased between T1 and T2. To determine how much each additional unit of gold must be deflated or discounted to off-set the inflation, one would use the following formula (assuming a constant population):

$$(w / x) / ((w + y) / x) = k_3.$$

The outcome of this computation is an inflation factor that can also be thought of as a weighting device. In this instance, because it is a period of inflation, the factor would be, in effect, a negative (the multiplier is less than 1.0) weighting: amount (w + y) would have to be discounted by the outcome of the computation (a proportion) for each "current" unit of gold to be

equal in value to the base year value of gold units. Similarly, if one knew that the amount of gold was being held constant but the population was increasing, the gold deflation rate would be determined by

$$(w / x) / (w / (x + z)) = k_4.$$

Of course, reality is not so accommodating to hold either gold or population constant. More gold is being mined and the population is changing, neither event occurring at constant rates. What this series of formulas must be able to address, then, is fluctuation in both the numerator and denominator when measured simultaneously at consecutive points in time. The formula

$$(w / x) / ((w + y) / (x + z)) = k$$

addresses such fluctuation. The outcome here is a quotient that results from the division of one tangible amount (number of units of gold per individual at T_1) divided by another tangible amount (number of units of gold per individual at T2). In this hypothetical situation where people are in competition with each other for more gold, this quotient may be considered to be a "competition factor." That is, recognizing that a certain number of people are competing for a certain number of gold units at each period of time, the quotient indicates how much the level of

competition at T_2, regardless of what it is, must be adjusted to make it equal to the level of competition that was present at T_1.

For example, if there were 4700 units of gold for 1375 people at T_1 (4700 / 1375 = 3.42 units of gold per person) representing the level of competition at T_1, and 5850 units of gold for 1500 people at T_2 (3.9 units of gold per person), representing the level of competition at T_2, (3.42) / (3.9) = .88, the competition factor. This quotient converts the level of competition present at T_2 into the level that was present at T_1.

There are several assumptions in the above scenario that must be explicitly recognized. First, although there is no explicit price or value placed on gold (e.g., the amount of gold one possesses cannot be readily translated into dollars), it is understood that everyone wants more, regardless of the current amount they possess. Second, while the amount of gold divided by the population results in a per capita figure, in the scenario above this per capita figure is only illustrative. Clearly some individuals in the population may possess more gold than others but it is assumed (by economists) that everyone wants more.

Third, the above represents a situation in which increases in supply and demand may occur at every price. Indeed, in this instance where supply and demand are not functions of pricing practices but rather linear functions of the number of individuals in competition with each other for the product at successive points in time regardless of its price, there are not any supply/demand curves. Instead, there are points representing supply and demand over time. Such a plotting of points over time

is more akin to the plotting of inflation rates or GNP than the plotting of supply and demand curves.

Methodology

Data Sources

There are four sources of data for this study. Two are Ulrich's International Periodicals Directory and The Annual Bibliography of English Language and Literature. Ulrich's is an annual publication that monitors all periodicals and categorizes them according the subject. In addition, it also gathers such data as when a particular periodical began publication, circulation, and how often the periodical is published. In essence, Ulrich's allows the number of journals in a given year to be readily determined without introducing potential bias in the form of the quality of the journals.7 Further, because Ulrich's is not concerned with the most important journals, it is possible to include in the study faculty at institutional types that probably do not frequently publish in the leading journals but who nonetheless do publish.

Ulrich's is the data source for the disciplines of biology and psychology (see below) as these disciplines are distinctly monitored. For the discipline of English, however, Ulrich's includes political essays in its categorization, making the category, for the purposes of this study, "unclean." This problem is remedied by the Annual Bibliography which monitors

7 Science Citation Index, for example, monitors only the "most important" or influential journals, thereby introducing a quality factor.

journals specific to English language and literature. Although it does not gather the same kinds of data as Ulrich's, it does list at the beginning of each annual issue the names of the journals it monitors, allowing the number of journals monitored for any given year to be counted. Like Ulrich's, the Annual Bibliography makes no claim that inclusion in its listing is based on quality.

The third source of data is American Universities and Colleges, published quadrennially by the American Council on Education. This publication contains information on virtually all institutions, including the number of faculty within specific departments. Consequently, rather than relying on data provided by the National Science Foundation or the Bureau of Labor Statistics which do not define, for example, a biologist in the same way, a random sample, stratified by institutional type, can be drawn from AUC to estimate the number of academic biologists in faculty positions at particular types of institutions.

The fourth and final source of data is the journals selected at random for analysis.

Data Collection

A specific discipline within each of the natural/physical sciences, social sciences, and arts and humanities fields was identified. The disciplines of biology, psychology, and English meet this criterion. Specific years during which levels of competition were to be determined were also identified. The year 1972 was selected because it is one economists have used as a base year in inflation studies. Further, it is also a year for which a national survey of faculty was conducted (Bayer, 1973), the results of which have helped to provide general contextual information for the base year. The year 1988 was selected because it is the most recent year for which complete data are available. The year 1980 was chosen because a midpoint provides two time intervals for analysis as opposed to one.

To determine the level of supply, Ulrich's and the Annual Bibliography of English Language and Literature were consulted. Appendix B shows that the number of journals within each discipline has grown between 1972 and 1988. In theory, journals could be randomly selected for each discipline at the three points in time and the average number of pages per issue computed. In reality, however, since all articles in all journals are not of the same page length nor does each journal carry the same number of articles per issue, standardization was necessary. The standardization process is described below.

First, because this study is interested in the amount of inflation or deflation of journal space as it affects United States faculty, only those journals in which U.S. faculty publish

on a "regular"[8] basis were included. This problem exists because Ulrich's monitors journals published around the world and not only journals published in the United States.

Second, to determine the growth/decline of publication units for which U.S. faculty are competing, a sample of 30 journals was selected for each discipline for each of the three years, yielding nine samples of 30. Of each of these samples, the University of Michigan library only subscribes to some particular percentage of the 30 journals for each discipline (see Discussion below and Appendix C). Each journal carried by the library was examined to see if it met the "one-third U.S. faculty" tests. Regardless of whether an individual journal met the test (if it did it was considered "useable" and the necessary data employed in the study was obtained), certain characteristics of the journal were noted, such as where published, its name[9], whether the name of the journal was in English or another language, whether published by a university press or a private press, whether the journal was monitored by an abstracting service and if so, how many, and whether the journal was an international journal. Assuming the information was provided by the respective

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8 For the purposes of this study, U.S. faculty publish "regularly" in a journal when they constitute at least one-third of the total authorship in an issue or when at least one-third of the articles in an issue have a U.S. co-author.

9 If the words "newsletter," "bulletin," or "directory" were included in the title, the "journal" (actually, the periodical) was considered non-useable. "Irregular" series and "annual" periodicals, often annual directories of professional societies were excluded, as were conference proceedings, annual reviews of research, handbook series, and the like. Monograph series ("Current Developments in ...", "Advances in ...") were considered useable, assuming they had been published at regular intervals over a period of several years.

journal editors to the compilers of Ulrich's, each of these characteristics is reported in each issue of Ulrich's. By compiling these identifying characteristics for both "useable" journals and "non-useable" journals in the 30 journal sample, it became possible to segregate all journals monitored by Ulrich's based on these identifying characteristics into useable and non-useable.

With these segregation criteria in hand, then, a sample of 20% (40% in the case of psychology) of all journals for each discipline in each year was selected and scrutinized against the criteria by examining the information provided in Ulrich's. By this process, the increase in the number of useable journals, representing the journals in which United States faculty members are competing to publish, was estimated. For the field of psychology, for example, the number of useable journals was estimated for the years 1972, 1980, and 1988, respectively, to be 98, 190, and 240.

Third, because the number of journals in the disciplines being studied is far too great to allow the counting of units for each journal even with the useable-non-useable distinction, a sample of 20 useable journals for each year and for each discipline was randomly selected. Once a journal was selected and determined to be useable (and assuming it was subscribed to by the University of Michigan library for the particular year), two issues were arbitrarily selected and examined. Data gathered from each issue were as follows: name of journal, volume number, issue number, how often published, number of articles per issue,

name of institution of each author (to insure that only faculty from the institutional types being examined were included in the analyses) and the number of authors per article, and the page length of each article. Decision rules that guided data collection at this step are provided in Appendix B.

As an example, this process yielded the following data for the field of psychology in 1972: Of the 390 journals monitored by Ulrich's, 98 were estimated to be useable. From a sample of 20[10] of the 98 useable journals (drawn randomly from the 390 until 20 were reached, not randomly from the 98), the average number of articles per journal per year was 64.95, and the average number pages per article was 6.99. The multiplication of pages by articles by journals produced the estimated available space within the discipline for 1972, 44,492 pages or "units" of knowledge.[11]

Finally, with respect to the quality of the periodicals that Ulrich's monitors, some are truly "scholarly" journals that publish only original empirical research and employ blind review

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10 Appendix C shows the number of journals randomly selected from Ulrich's to obtain a yield of 20 useable journals.

11 In considering the use of the data in the manner described above, there are some limitations to the data. Starting with the development of the supply index, while the problem of different page length of articles has already been alluded to, other similar limitations are present. For example, if page length of articles is being standardized, one could argue that font size of print and the subsequent number of words per article should also be standardized. Although there have been changes in presentation within given journals over the years (e.g., having gone from a two column format to a one column format), it does not seem likely that changes made below the page length per article level will greatly influence the results.

while other journals that are monitored rely largely on the interest(s) of the editor(s) and publish work that, perhaps, integrates original research conducted by others. To the extent that newsletters and the like were excluded from the analyses, an effort has been made to keep the study focused on research productivity. However, no attempt was made to examine the editorial practices of any of the journals to ensure that only those journals that publish original empirical work were included. Some non-research articles or journals may have been included in the analyses and therefore contaminated the study. Since this study is not addressing issues of what is and is not a *bona fide* research article, such contamination is recognized, presumed to be randomly distributed throughout the study, and accepted as a limitation.

Determination of the level of demand occurs in much the same fashion as did the determination of the level of supply. The first analytical issue on the demand side concerns whether faculty at institutions not included in the study (liberal arts colleges and two year colleges) publish at high enough levels that their inclusion is warranted. The assumption for the purposes of this study is that they do not. While exclusion of liberal arts and 2 year college faculty from the study does introduce some bias, it is not so great that it prohibits the painting of a clear research productivity portrait.

Considering only Research, Doctoral-granting, and Comprehensive institutions, then, a random sample of institutions

from the six institutional types was selected and the number of full-time ranked faculty within the three departments recorded for each of the three years[12]. Of the 626 Research, Doctoral-Granting, and Comprehensive institutions in 1972, 76 biology, 69 psychology, and 73 English departments were sampled. For 1980 (778 institutions) and 1988 (814 institutions) respectively, the number of departments sampled were 60 and 34 for biology, 57 and 39 for psychology, and 55 and 39 for English. The level of demand was developed by multiplying the average department size by the total number of institutions, the product being an estimation of the total number of faculty within the respective disciplines and institutional types for the specific years.

Results

Starting at the most general level, the analysis of the randomly selected journals and the randomly selected institutions show that the number of pages available to faculty has increased during both periods of time (1972 to 1980 = T_1; 1980 to 1988 = T_2) while the number of faculty decreased during T_1 and then rebounded during T_2. The division of available page space by the number of faculty yields the average number of pages available per faculty member. The following are the data for psychology.

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12 When applicable, faculty in professional schools (e.g., veterinary, medical) were also included if their specialization was listed as a specialization monitored by Ulrich's (e.g., physiologists are in biological sciences departments and in medical schools).

	1972	1980	1988
NUMBER OF PAGES AVAILABLE:	44,492	56,139	101,476
NUMBER OF FACULTY:	8,996	8,698	11,624
AVAILABLE PAGES PER FAC.:	4.95	6.45	8.72

From these data it can be seen that the average available spaces per faculty member has been increasing over time. Or, stated differently, the level of competition has decreased over time (increases in supply have exceeded increases in demand). It can also be seen that by dividing the available pages per faculty member in 1972 (4.95) by the available pages in 1980 (6.45) the "deflation factor" results, indicating the extent to which the pages per faculty member ratio in 1980 must be reduced to bring them "down" to the 1972 level; the increased availability must be discounted and returned to the 1972 level to allow for subsequent computations to occur in constant units of measure. The deflation factor for 1980 is .77; for 1988 .57. The deflation factor for converting 1988 page availability into 1980 availability is .74.

Moving to a more specific level, the journals also revealed the following information:

	1972	1980	1988
NUMBER OF JOURNALS (that meet "useability" criteria defined above)	98	190	240
AVERAGE PAGES PER ARTICLE	6.99	10.56	11.68
AVERAGE NUMBER OF AUTHORS PER ARTICLE	1.85	1.76	1.86
AVERAGE NUMBER OF PAGES PER AUTHOR	3.79	5.99	6.28

These additional data allow the conversion of 1980 or 1988 "current" articles into 1972 "standard" articles via the following process:

1) CURRENT ARTICLES x CURRENT AVERAGE PAGES PER AUTHOR = CURRENT PAGES PER AUTHOR;

2) CURRENT PAGES PER AUTHOR x DEFLATION FACTOR = DEFLATED PAGES PER AUTHOR [=1972 pages];

3) DEFLATED PAGES PER AUTHOR / AVERAGE PAGES PER ARTICLE IN 1972 = NUMBER OF 1972 ARTICLES.

To see how the process works at a less abstract level, consider the hypothetical faculty member who published 4 articles in 1972, 7 articles in 1980, and 13 articles in 1988.

	1972	1980	1988
1)	(4)(3.79)=15.16	(7)(5.99)=41.93	(13)(6.28)=81.64
2)	(15.16)(1)=15.16	(41.93)(.77)=33.29	(81.64)(.57)=46.53
3)	(15.16)/(6.99)=2.16	(33.29)/(6.99)=4.62	(46.53)/(6.99)=6.66

From the results on line (3) it can be seen that although this individual's productivity has been increasing steadily over time, seven articles in 1980 equals only 4.62 "standard" articles and thirteen 1998 articles equals only 6.66 standard articles. But how, the reader may ask, can four 1972 articles equals only 2.17 standard articles when those four articles were produced in the standard year? The answer is that the average article in 1972 had 1.85 authors; (4)/(1.85)=2.17.

To the extent that individuals do publish single-author articles, the process is adaptable to specific individual cases. Consider another hypothetical faculty member who in 1972 published three "solo" articles and two "partial" articles; in 1980 four solos and 3 partials; and in 1988 5 solos and 4 partials. The computation for this individual is

	1972	1980	1988
	(6.99)(3)+(3.78)(2) =28.53	(10.56)(4)+(5.99)(3) =60.21	(11.68)(5)+(6.28)(4) =83.52
	(28.53)(1)=28.53	(60.21)(.77)=46.36	(83.52)(.56)=46.77
	(28.53)/(6.99)=4.08	(46.36)/(6.99)=6.63	(46.77)/(6.99)=6.69

Given the increase in available journal space over time, this individual was not appreciably more productive in 1988 than in

1980 although he/she published one more single-author piece and two more joint-author pieces in 1988 than in 1980. Via this process, then, it is possible to convert any combination of single-author and joint-author articles published in subsequent years into standard articles.

Returning to the hypothetical faculty member who published four, seven, and thirteen articles in 1972, 1980, and 1988 respectively, two more points warrant comment. First, with the deflating process described above, one can also determine the "conversion factor" for each year that, when multiplied by the current year number of articles, generates the equivalent number of standard year articles. This conversion factor is derived by dividing the standard year number of articles (after being determined via the process once) by the number of current year articles. The conversion factor for converting 1980 articles into standard articles is (4.62)/(7)=.66; the conversion factor for converting 1988 articles into standard articles is (6.54)/(13)=.50. Once these conversion factors are determined, the process need not be gone through again. Current year articles need only be multiplied by the conversion factor and standard articles are achieved.

Second, it is obvious that 1988 articles can also be converted into 1980 articles.

1980	1988
(7)(5.99)=41.93	(13)(6.28)=81.64
(41.93)(1)=41.93	(81.64)(.73)=59.6
(41.93)/(10.56)=3.97	(59.6)/(10.56)=5.64

The conversion factor for converting 1988 articles into 1980 articles is (5.64)/(13)=.43.

Finally, consider the individual that published one article in each of the years 1972, 1980, and 1988. To what extent has her or his productivity dropped over time due to inflation of available journal space? Very simply, assuming joint-authorship for each article, her or his productivity was .54 in 1972, .66 in 1980, and .50 in 1988. The interpretation of this individual's productivity is that he or she has remained relatively constant; the inflation of space (available pages) has been offset by the fact that the average number of pages per article has been increasing over time as well.

Discussion/Implications

As for the limitations of this inquiry, there are essentially three. The first arises from the library holdings of the University of Michigan. While the university's holdings are among the best in the country, it does not hold a subscription to every journal monitored by Ulrich's or the Annual Bibliography. The bias introduced into the study as a result of limited library holdings is presumably small. However, we are currently devising

a method to determine what type of bias using only the University of Michigan library has introduced.

A second limitation concerns the assumption that every faculty member is interested in publishing. If this is not the case, adjustments take the form of decreasing the denominator by some proportion when calculating the available space per faculty member at every time period. Again, we recognize the potential bias and are currently investigating data sources and methods for addressing this issue.

The third and final limitation turns on the assumptions that were made on how to sample, what to count, and the like. Each of these has been detailed in the text of the article. To the extent that these critical decisions are accepted, so then are the conclusions since what follows is simply deductive mathematics. We believe what we found to be true.

Turning to the principal findings of the investigation, several seem striking. To begin, there is the tremendous growth in the space available for faculty publishing. It is nearly double in 1988 what it was in 1972. Furthermore, all of those pages have been filled, and by a comparatively small increase (%) in the number of faculty in the system. Faculty who complain that they can not keep up with their journal reading have a good reason to be behind. Institutional demands for increased publication have been increasing at places where they have been rewarded for a long time. In addition, they have been spreading to places where they were limited or even non-existent. Not only

are more faculty publishing than ever before--and fewer not publishing--but also established researchers are publishing even more than they previously did.

Second, faculty increased effort to publish needs to almost double in order to produce the same amount today as they did in 1972. In 1972 units, a 1988 article is only about half what it was then.

There are some subtle contradictions in faculty conversations regarding the journal publication world. Faculty know that their vita and that of their colleagues show a growing list of new additions to their publication's section, the most recent year being higher than the preceding, those of the newly hired longer than the previously hired. At the same time--especially in the social sciences--faculty bemoan the 85% rejection rate, the difficulty of getting a paper accepted, the amount of revision called for, the increased period of time the review process takes. It does not seem as if both conditions can be simultaneously true.

Consider the following possibility as an explanation for what is going on. Experienced journal editors say the submission rate has not been noticeably changing the past few years. They also say that the rejection rate has remained essentially constant. But these are in the leading journals in the field. One might have thought as the number of contestants for journal space increases and those already engaged in the activity accelerate their output that both submission rates and rejection

rates would increase together. But these are for the leading journals in the discipline. Maybe authors are directing their manuscripts toward the newly created journals where space is more accessible?

Other faculty (e.g., economists) believe that doing a study today is much more complex and involved today than it was yesterday. A first class piece of research now requires a gigantic data base and the most sophisticated treatment of data. One person cannot carry this off by herself or himself. It takes a combination of expertises to produce an acceptable article for the best science journals today, and a longer time to do it. If this is true, and this is what many faculty believe to be the case, how can individual publication rates go up? Simple. Be a joint author. You have to be anyhow. Every publication can be listed on the vita, irrespective of the number of authors or the individuals location in the list--as long as it is first once in a while. Wilner (1985), for example, has shown in sociology that the number of single authored articles has dropped from 69% to 2% between 1936 and 1982. Bayer and Smart (1988) have also found increases in the number of authors per articles. Fogel and Engerman (1983) write about teams of scholars being the hallmark of cliometric history in economic history today and point with pride to an article that "involved no fewer than ten authors." (However, our data for psychology do not show an increase in the number of joint authors over the time span covered.)

Two other points need to enter the discussion. One is our assumption that a page is a "unit of knowledge," whatever that may actually mean. While this is somewhat unconventional (articles are more typically thought to be the "unit of knowledge"), the justification for this assumption lies with the fact that knowledge is spread, roughly equally, throughout an article; it is not only contained in the first page of the results section or the last page of the theoretical framework. To leave out a page of an article is to leave out some piece of knowledge and so each page must be represented, as we have done with this study.

Second, of course, is the related and equally important issue of the quality of scholarly output, today versus yesterday. Quantity is of a secondary concern, especially when it is known that such a high proportion of what is published is never cited by anyone. If it is never used by anyone, it might just as well not exist.

We believe most would say that quality has improved dramatically over the past two decades. Articles that were accepted and published in leading journals in 1972 would not even be sent out for review today--or accepted at the less highly regarded journals. The change over time is probably true for in many fields the advances in theory and have been significant. Certainly the equipment has improved and so have the means for dealing with large quantities of data with more sophisticated analytical techniques. But it is not immediately obvious that

the elusive concept of "quality" has changed to the same degree. After all, a 1972 article may have been a state of the art piece--in 1972.

We are launching a study to see if we can ascertain the degree to which the quality of scholarly work has changed over this same time period. If we are successful here, we can then return to the quantity issue and place those findings in a more complete perspective.

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APPENDIX A

Growth of journals by discipline, 1972-1988

BIOLOGY

YEAR	# OF JOURNALS (TOTAL)	CHANGE SINCE: 1972	1980
1972	1894		
1980	2269	20% ++	
1988	2852	51% ++	26% ++

ENGLISH

YEAR	# OF JOURNALS (TOTAL)	CHANGE SINCE: 1972	1980
1972	766		
1980	1358	77% ++	
1988	1304	70% ++	4% --

PSYCHOLOGY

YEAR	# OF JOURNALS (TOTAL)	CHANGE SINCE: 1972	1980
1972	390		
1980	590	52% ++	
1988	764	96% ++	29% ++

APPENDIX B

Decision rules that guided the collection of data.

-- Each author was given 1/n credit with respect to page production; no weighting scheme was developed that gave the first or principal author, for example, the most credit, the second author somewhat less credit, and the third, fourth, etc... authors equal amounts of credit.

-- With respect to authorship by graduate students (either singly or as team members with other graduate students or faculty), non-United States faculty, and private sector (non-institutionally affiliated) contributors, because such authors are not in direct competition with full-time U.S. faculty, they have been excluded from the analyses. The exclusion was accomplished by disregarding the amount of space (number of units) that such individuals consumed. If, for example, a journal issue contained 8 articles of 10 pages each and two of the articles were authored by international faculty, only the number of authors from the remaining 6 articles (the U.S. faculty) were included in the computing of the level of demand and the number of pages included in the level of supply was 60. The same process was applied to American research scientists and their publications when it was clear that such scientists did not hold a concurrent faculty appointment.

-- If an author was a master's student, that contribution was not counted; if the work was part of a dissertation and the individual is now a faculty member, the contribution was counted; if the work was part of a dissertation but the person was not listed as a faculty member, the work was not counted; in every instance where determinable, a person's present or current address was used for analysis.

-- To be included in the analyses a person's biographical sketch had to include "Dept. of ...., University of ..."; "Institute of Molecular Biophysics, Florida State U" would not count nor would "Dept. of Applied Science, Brookhaven National Lab"; if they were part of an institute and part of a department, they were included; while this decision was applied, it only does a partial cleaning of the data because some journals would have only listed "Florida State U" and if that were the case, the person would have been counted.

-- If only an institution was listed in the biographical sketch of an author without a rank, it was assumed the person was a full time faculty member.

-- If there were five authors to an article and only three institutions listed with no indication of who worked where, arbitrary decisions were made about who belonged where, such as two authors to the first institution listed, two to the second, and one to the third (this doesn't affect anything as long as all three institutions are of the type included in the study; if not, there is some kind of bias introduced).

-- Journals that gave no biographical information on the authors were not analyzed.

-- Generally research notes, technical notes, methodological notes, book reviews, etc... were excluded from analysis as were opinion pieces (when determinable), replies to criticisms, letters of criticisms, letters to editors, and the like. Occasionally review articles were included if they were of comparable length to regular articles and there appeared to have been some amount of research involved (e.g., a decent length bibliography).

-- When an exact year for a journal was not available, issues from a close year (e.g., '79 or '81) were selected and analyzed.

APPENDIX C

Number of journals randomly selected, and then found, to obtain 20 "useable" journals per year for psychology.

	1972	1980	1988
NUMBER OF JOURNALS RANDOMLY SELECTED:	113	131	166
NUMBER OF JOURNALS HELD BY LIBRARY:	39	45	45
NUMBER OF USEABLE JOURNALS:	20	20	20